Technology, Innovation & Engineering Committee Report
NASA Advisory Council

Dr. Bill Ballhaus | 12.10.18

TI&E Committee Scope

“The scope of the Committee includes all NASA programs focused on technology research and innovation.”

–NASA Advisory Council Technology & Innovation Committee Terms of Reference, signed 6/28/12

TI&E Committee Meeting Attendees: Dec. 7, 2018

- Dr. William Ballhaus, Chair (online)
- Mr. Jim Free, Peerless Technologies
- Dr. Kathleen C. Howell, Purdue University
- Mr. Michael Johns, Southern Research Institute
- Dr. Matt Mountain, Association of Universities for Research in Astronomy
- Dr. Mary Ellen Weber, Stellar Strategies, LLC

Space Policy Directive-1

On December 11, 2017, President Trump set America's sights toward the stars by signing Space Policy Directive-1, which instructed the National Aeronautics and Space Administration (NASA) to return American astronauts to the moon for long-term exploration and utilization, followed by human missions to Mars and other destinations.

Technology Budget Challenges

The Space Policy Directive-1 provides a near-term destination for which a detailed program plan could be formulated along with required technologies and need dates.

- Over recent years, technology budgets have been disadvantaged by a lack of an urgency argument.
  - There was no overarching agency exploration architecture and plan.
  - We knew what technologies needed to be developed to get humans to Mars, we just didn't know when we would need them.
- Now there's an opportunity to develop a baseline architecture and project plan "*to return American astronauts to the moon for long-term exploration and utilization, followed by human missions to Mars and other destinations.*"

March 2012: T&I Committee Agency-Level Observations

NASA "grand" missions are technology-enabled.

- JWST, MSL, ISS—type of work NASA should be doing
- Demonstrates NASA/U.S. technical leadership

"Future U.S. leadership in space requires a foundation of sustained technology advances…NASA's technology base is largely depleted." –NRC Report

Technology Triumph

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Did you watch @NASAInSight's #MarsLanding? The live Mars mission was broadcast live today on the @Nasdaq tower in #TimesSquare with @NASA team members in attendance! Congratulations @NASAJPL/@NASA on a successful landing.

July & Nov. 2016: TI&E Observations

- **NASA needs cutting edge technologies to undertake its missions.**
  - Current missions are based on technologies developed through investments made over several decades.
- **In the timeframe FY2005-FY2009, technology budgets (basic research -$500M; applied research -$900M) were drastically reduced**
- **To reverse this decline, NASA established OCT (in 2010) and STMD (in 2013) and rebuilt the crosscutting technology program as well as made focused investments in technology development in HEOMD and SMD.**

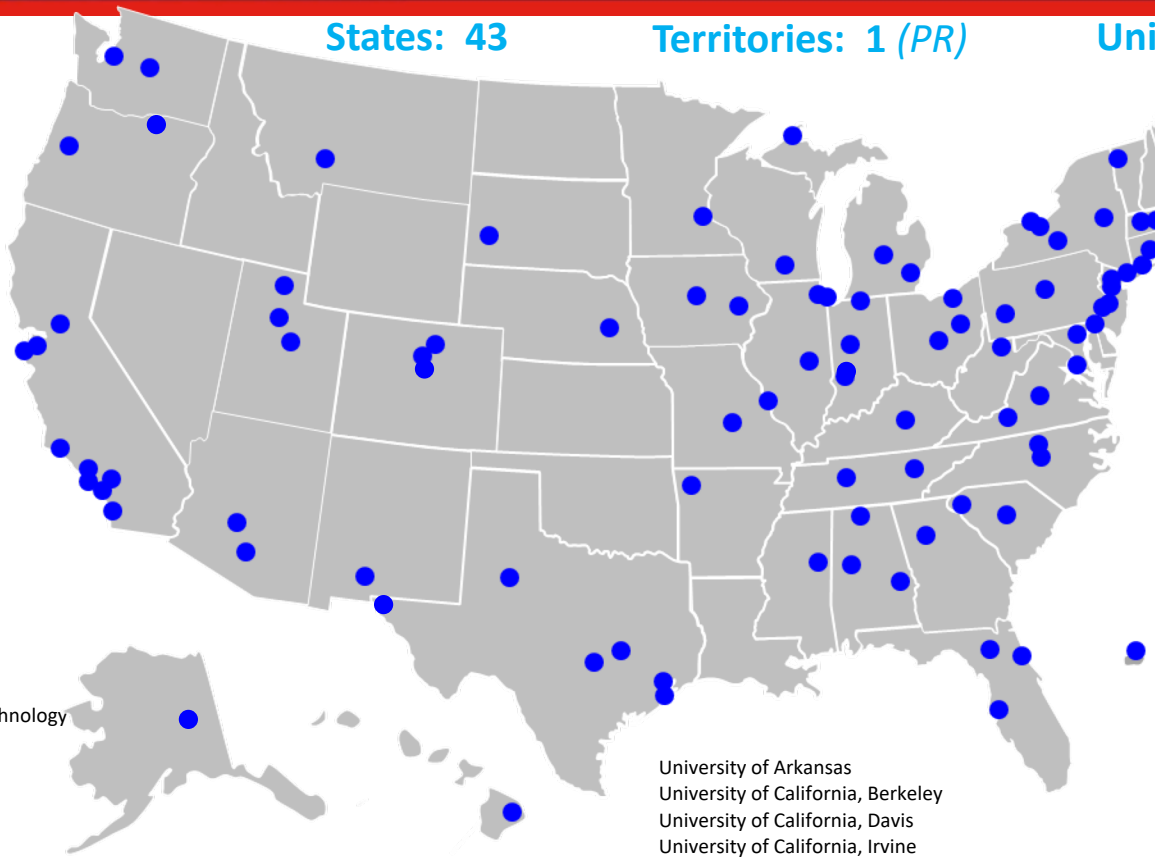
July 2015: TI&E Committee Observation

STMD University Engagement:

- During the mid-2000s, NASA's university engineering research programs were decimated.
- STMD has reestablished contacts with the university community through the Space Technology Research Grants program, including the NASA Space Technology Research Fellowship program.
- Committee met at lunch with 15 Fellows working at JPL this summer from universities across the nation
- Committee very impressed with technical knowledge and capabilities of the Fellows

STRG Portfolio – Awards To-Date
Universities

Awards: 595 **States: 43** **Territories: 1 *(PR)*** **Universities: 107**



Arizona State University
Auburn University
Boston University
Brigham Young University
Brown University
California Institute of Technology
Carnegie Mellon University
Case Western Reserve University
Clemson University
Colorado State University
Colorado School of Mines
Columbia University
Cornell University
Duke University
Florida Institute of Technology
Georgia Institute of Technology
Harvard University
Illinois Institute of Technology
Iowa State University
Johns Hopkins University
Massachusetts Institute of Technology
Michigan State University
Michigan Technological University
Mississippi State University
Missouri University of Science and Technology
Montana State University
New Jersey Institute of Technology
New Mexico State University
New York University
North Carolina State University
Northeastern University
Northwestern University
Ohio State University
Oregon State University
Pennsylvania State University
Portland State University
Princeton University
Purdue University
Rensselaer Polytechnic University
Rochester Institute of Technology
Rose-Hulman Institute of Technology
Rutgers University
South Dakota School of Mines and Technology
Stanford University
State University of New York, College of Nanoscale Science & Engineering
State University of New York, Stony Brook
Texas A&M University
Texas Tech University
Tufts University
University of Akron
University of Alabama, Huntsville
University of Alabama, Tuscaloosa
University of Alaska, Fairbanks
University of Arizona
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University of California, Berkeley
University of California, Davis
University of California, Irvine
University of California, Los Angeles
University of California, San Diego
University of California, Santa Barbara
University of Central Florida
University of Colorado, Boulder
University of Connecticut
University of Delaware
University of Florida
University of Hawaii
University of Houston
University of Illinois, Chicago
University of Illinois, Urbana-Champaign
University of Iowa
University of Kentucky
University of Maine
University of Maryland
University of Massachusetts, Amherst
University of Massachusetts, Lowell
University of Michigan
University of Minnesota
University of Nebraska, Lincoln
University of New Hampshire
University of Notre Dame
University of Pennsylvania
University of Pittsburgh
University of Puerto Rico, Rio Pedras
University of Rochester
University of South Carolina
University of South Florida
University of Southern California
University of Tennessee
University of Texas, Austin
University of Texas, El Paso
University of Utah
University of Vermont
University of Virginia
University of Washington
University of Wisconsin, Madison
Utah State University
Vanderbilt University
Virginia Polytechnic Institute & State University
Washington State University
Washington University, St. Louis
Western Michigan University
West Virginia University
William Marsh Rice University
Worcester Polytechnic Institute
Yale University

July & Nov. 2016: TI&E Observations

- **NASA management has done an excellent job of formulating the technology program and executing it, within annual budget constraints.**
  - Examples of past accomplishments (2010 to 2015): Composite Cryotank, Advanced Solar Arrays, High Power Electric Propulsion Thrusters, EDL including inflatable decelerators, High Performance Thermal Protection Systems, BEAM (Commercial Inflatable Habitat at ISS), and Small Spacecraft Technologies
  - Examples of upcoming accomplishments (2016 to 2020): Green Propellant Infusion Mission (GPIM), Deep Space Atomic Clock (DSAC), Solar Electric Propulsion demo, laser comm demos, RESTORE–L satellite servicing demo, in-space robotic manufacture & assembly, ISRU demo and Terrain Relative Navigation on Mars 2020
- **STMD reengaged the academic community in engineering research and technology development and has rekindled interest in NASA among students, especially at the graduate level.**
- **STMD has effectively used internal and external partnerships to mature and develop technologies.**

March 2018: TI&E Committee Finding

NASA's major missions have been enabled by technology investment over a number of years.

Previous experience with housing "seed corn" and crosscutting technologies in development mission directorates produced unfortunate results

- Drastic reductions in those technology budgets
- Alienation of university connections—the major source of human capital for NASA and its contractors

STMD was established to reverse these outcomes and has produced a robust technology portfolio with university and industry partnerships.

Question: With the potential demise of STMD, how would NASA in its new structure assure future such unfortunate results don't materialize?

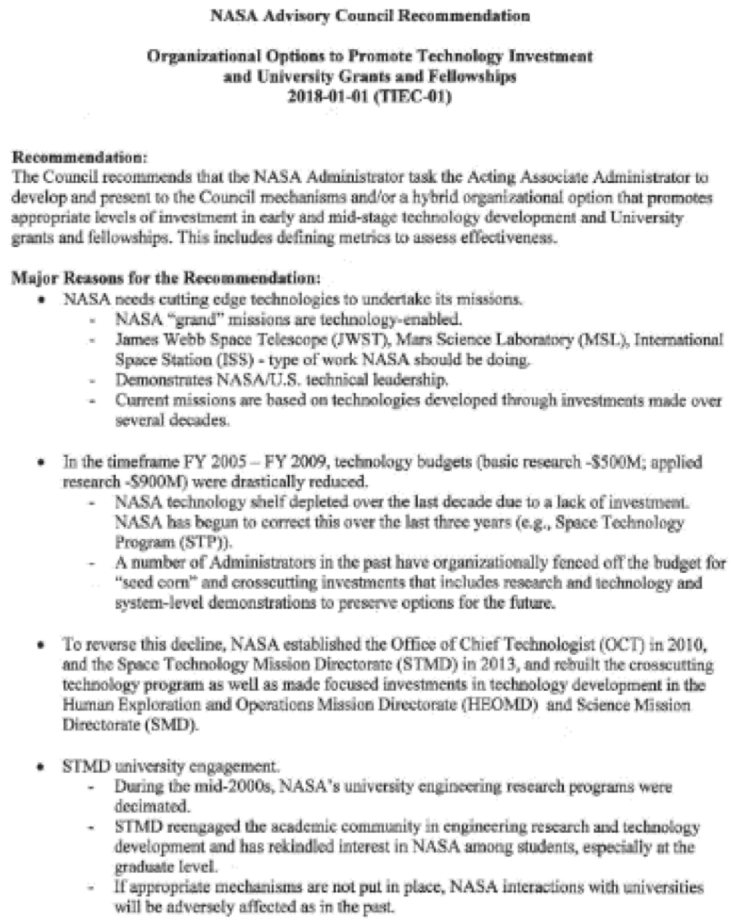
August 2018: NAC Recommendation

NAC Recommendation (March 2018)

"The Council recommends that the NASA Administrator task the Acting Associate Administrator to develop and present to the Council mechanisms and/or a hybrid organization that promotes appropriate levels of investment in early and mid-stage technology development and University grants and fellowships. This includes defining metrics to assess effectiveness."

NASA Response

"NASA concurs. This recommendation is being addressed within the larger context of an Agency restructuring activity led by the Associate Administrator. As soon as the Administrator makes a final decision on restructuring the Agency and has briefed various stakeholders, the Associate Administrator will brief the NASA Advisory Council on the Agency restructuring including how the new structure will ensure appropriate levels of investments in early and mid-stage technology development and university grants and fellowships. It is anticipated this briefing will occur at the NASA Advisory Council meeting this summer."



NASA Advisory Council Recommendation

Organizational Options to Promote Technology Investment and University Grants and Fellowships
2018-01-01 (TIEC-01)

Recommendation:
The Council recommends that the NASA Administrator task the Acting Associate Administrator to develop and present to the Council mechanisms and/or a hybrid organizational option that promotes appropriate levels of investment in early and mid-stage technology development and University grants and fellowships. This includes defining metrics to assess effectiveness.

Major Reasons for the Recommendation:

- NASA needs cutting edge technologies to undertake its missions.
  - NASA "grand" missions are technology-enabled.
  - James Webb Space Telescope (JWST), Mars Science Laboratory (MSL), International Space Station (ISS) - type of work NASA should be doing.
  - Demonstrates NASA/U.S. technical leadership.
  - Current missions are based on technologies developed through investments made over several decades.
- In the timeframe FY 2005 – FY 2009, technology budgets (basic research -$500M; applied research -$900M) were drastically reduced.
  - NASA technology shelf depleted over the last decade due to a lack of investment. NASA has begun to correct this over the last three years (e.g., Space Technology Program (STP)).
  - A number of Administrators in the past have organizationally fenced off the budget for "seed corn" and crosscutting investments that includes research and technology and system-level demonstrations to preserve options for the future.
- To reverse this decline, NASA established the Office of Chief Technologist (OCT) in 2010, and the Space Technology Mission Directorate (STMD) in 2013, and rebuilt the crosscutting technology program as well as made focused investments in technology development in the Human Exploration and Operations Mission Directorate (HEOMD) and Science Mission Directorate (SMD).
- STMD university engagement.
  - During the mid-2000s, NASA's university engineering research programs were decimated.
  - STMD reengaged the academic community in engineering research and technology development and has rekindled interest in NASA among students, especially at the graduate level.
  - If appropriate mechanisms are not put in place, NASA interactions with universities will be adversely affected as in the past.

We stand by our concerns and the Council's recommendation

Some historical context…

Transcript, James E. Webb Oral History Interview, 4/29/69, LBJ Library.

Did Mr. Johnson ever discuss with you the allocation of priorities within NASA? That is, one assumes that because of the budget cuts, you were having to look again at your priorities inside the NASA.

Webb: Yes, he and Kennedy both on a small number of occasions, … would raise the question, *"Why don't you stop these other things and finish the lunar thing to which we are politically committed?"*

And my answer was always, ***"It's too important. And so far as I'm concerned, I'm not going to run a program that's just a one-shot program. ….. it's going to be a balanced program that does the job for the country that I think has got to be done under the policies of the 1958 Act."***

Some more historical context…

National Aeronautics and Space Act of 1958 (Unamended)

The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:

(1) The expansion of human knowledge of phenomena in the atmosphere and space vehicles

(2) The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles

(3) The development and operation of vehicles capable of carrying instruments, equipment, supplies and living organisms through space;

(4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes.

(5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere.